Effect of alpine plant species on *in vitro* ruminal fermentation characteristics

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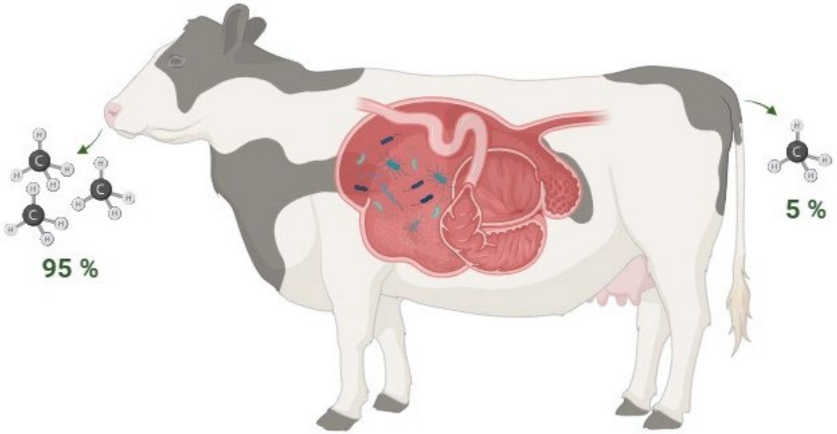
75th EAAP Annual Meeting
Florence – Italy

Introduction



Ruminal fermentation → Methane production

→ 3.3% to the total greenhouse gas emissions

(*Knapp et al. 2014*)

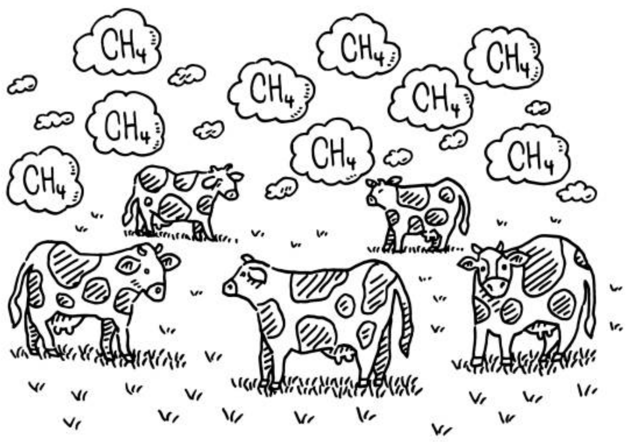
→ significant **inefficiency** in feed utilization

↓

gross energy loss of around **2 to 12%**

(*Johnson & Johnson 1995*)

Introduction



To reduce CH4 emissions

↓

Diet management

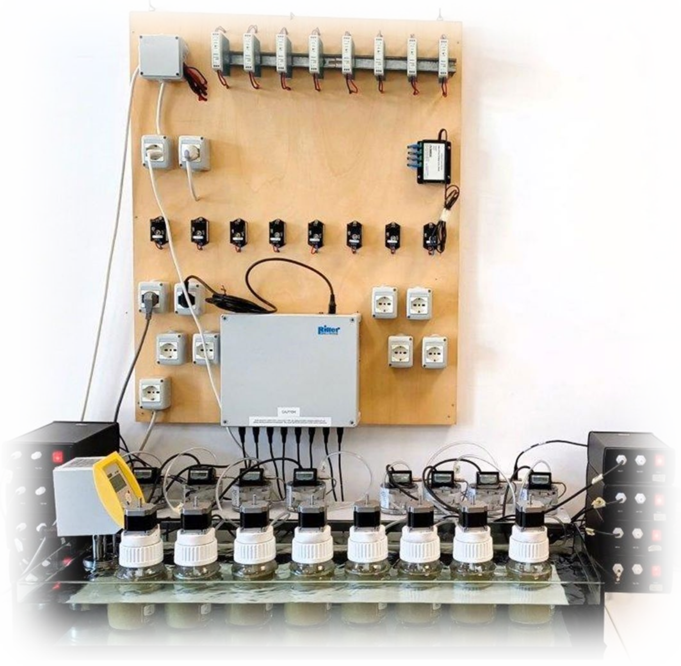
↓

effect of different **plant species** on:

methane production

ruminal fermentation parameters

***in vitro* system for continuous measurement**



Materials And Methods – Plant sampling

11 plant species → sampled at the start of the **grazing season**

grazing dairy cows' **diets** →

1. availability
2. palatability

plant was cut about **3 cm** above the ground → **0.5 kg** of fresh matter was collected for each → vacuum packed stored at refrigeration temperature (**4°C**)

Materials And Methods - Plants

Achillea millefolium
Common yarrow

Carum carvi
Caraway

Festuca rubra
Red fescue

Hypericum maculatum
Imp. St John’s wort

Lotus corniculatus
Bird's-foot trefoil

Poa alpina
Alpine bluegrass

Potentilla erecta
Tormentil

Prunella grandiflora
Large selfheal

Ranunculus acris
Buttercup

Trifolium repens
White clover

Veronica chamaedrys
Germander speedwell

Materials And Methods – *In vitro* trial

Plants used as **fresh substrate**

same level of DM (3300 mg) in all fermenters

roughly cut and **smashed manually**

fermentation bottle (500 mL)

rumen fluid

buffer solution

were incubated **24 hours at 39 °C**

during incubation gas and **methane** production were monitored **continuously**

Statistical Analysis

Balanced incomplete block design
(Cox and Reid,2000)

11 fermentation runs

five distinct fermentation runs (each plant)

Gompertz model

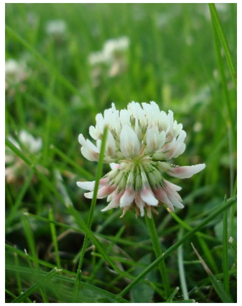
percentage of methane in total gas recorded **each hour** from **each fermentation bottle**

$$Y_t = B(exp^{(-Cexp^{-At})})$$

Results and Discussion

Proximal composition of plants used in the *in vitro* trial

L. corniculatus



T. repens

F. rubra

P. alpina

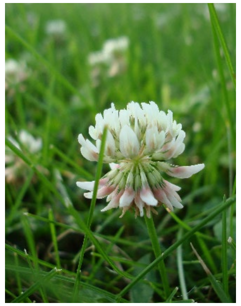
	DM	Composition (% DM)					
		CP	NDF	ADF	ADL	Ash	EE
Achillea millefolium	25.7	16.8	49.2	26.4	8.06	7.73	2.02
Carum carvi	18.5	16.1	41.9	24.5	6.15	9.29	1.72
Festuca rubra	40.3	7.59	74.8	40.7	5.77	2.53	1.50
Hypericum maculatum	31.7	11.5	56.2	38.4	21.7	5.57	1.61
Lotus corniculatus	22.5	20.3	42.6	24.9	10.4	7.37	1.92
Poa alpina	43.7	6.92	69.1	34.7	4.48	2.78	1.96
Potentilla erecta	32.2	12.0	51.6	28.8	8.70	5.20	1.41
Prunella grandiflora	20.5	10.6	42.8	24.0	10.2	8.61	1.22
Ranunculus acris	23.0	8.90	51.7	32.1	8.00	5.83	2.18
Trifolium repens	23.0	24.6	35.9	19.9	6.16	10.7	1.85
Veronica chamaedrys	28.0	11.4	44.5	27.3	11.7	6.28	0.76

Results and Discussion

Fermentative traits obtained after 24 hours of *in vitro* fermentation

H. maculatum

P. alpina



T. repens

P. grandiflora

	Total VFA (mM)	% Total VFA			C2:C3	NH3 (mg/dL)
		C2	C3	C4		
Achillea millefolium	36.4	71.4^{abc}	12.9^{abc}	11.3^{ab}	5.57^{ab}	60.9^{ab}
Carum carvi	36.3	72.0^{abc}	13.7^{ab}	10.3^{ab}	5.36^{b}	55.4^{abc}
Festuca rubra	38.6	70.0^{bc}	13.2^{ab}	12.3^{ab}	5.37^{b}	55.6^{abc}
Hypericum maculatum	26.3	74.4^{a}	11.2^{c}	10.5^{ab}	6.75^{a}	53.1^{abc}
Lotus corniculatus	29.5	70.8^{abc}	13.5^{ab}	12.1^{ab}	5.34^{b}	56.5^{ab}
Poa alpina	34.6	69.2^{c}	14.0^{a}	12.3^{ab}	4.93^{b}	60.2^{ab}
Potentilla erecta	32.8	72.6^{abc}	12.0^{bc}	11.3^{ab}	6.10^{ab}	50.4^{bc}
Prunella grandiflora	28.4	71.6^{abc}	12.2^{abc}	13.0^{a}	5.97^{ab}	42.5^{c}
Ranunculus acris	34.8	73.3^{ab}	12.3^{abc}	10.6^{ab}	5.97^{ab}	55.0^{abc}
Trifolium repens	50.4	73.9^{a}	12.6^{abc}	9.43^{b}	6.17^{ab}	65.5^{a}
Veronica chamaedrys	35.9	71.8^{abc}	13.1^{bc}	11.3^{ab}	5.48^{ab}	50.3^{bc}
Significance	NS	**	**	**	**	**
RMSE	11.5	1.57	0.77	1.33	0.56	5.98

Results and Discussion

Gas and methane values after 24 hours of *in vitro* fermentation

C. carvi

P. erecta

F. rubra

R. acris

	Gas (mL/g DMD)	Methane (mL/g DMD)	Methane (%)
Achillea millefolium	432[ab]	106[ab]	27.8[ab]
Carum carvi	523[a]	126[a]	24.5[ab]
Festuca rubra	398[abc]	112[a]	28.9[a]
Hypericum maculatum	254[bc]	64.6[ab]	25.3[ab]
Lotus corniculatus	319[abc]	80.7[ab]	24.9[ab]
Poa alpina	339[abc]	89.2[ab]	26.7[ab]
Potentilla erecta	191[c]	49.2[b]	24.6[ab]
Prunella grandiflora	303[abc]	79.8[ab]	26.6[ab]
Ranunculus acris	513[a]	122[a]	24.2[b]
Trifolium repens	253[bc]	65.3[ab]	26.6[ab]
Veronica chamaedrys	312[abc]	73.7[ab]	24.3[ab]
Significance	**	**	*
RMSE	103	26.8	1.99

Results and Discussion

Kinetics parameters

- **A** is a constant that describes the decline of the production rate
- **B** is the asymptotic methane volume
- **C** is the specific CH_4 production rate dependent on time
- **TMFR** is the time to maximum fermentation rate
- **MFR** is the maximum fermentation rate
- **Lag** is the lag phase.

	A	B, %	C, 1/h	TMFR, h	MFR, %/h	Lag, h
Achillea millefolium	0.82^{bcd}	25.0^{bc}	4.57	2.22^{cde}	7.62^{ab}	0.72
Carum carvi	1.02^{a}	24.5^{c}	4.87	1.87^{e}	8.88^{a}	0.60
Festuca rubra	0.38^{f}	29.1^{a}	4.07	3.57^{a}	4.00^{d}	0.84
Hypericum maculatum	0.49^{ef}	23.9^{c}	2.98	2.64^{bc}	4.58^{cd}	0.37
Lotus corniculatus	0.75^{cd}	24.9^{c}	4.73	2.26^{cde}	6.89^{abc}	0.73
Poa alpina	0.43^{f}	28.8^{a}	4.30	2.88^{b}	4.89^{cd}	0.73
Potentilla erecta	0.37^{f}	26.1^{abc}	2.62	2.31^{bcde}	3.51^{d}	0.20
Prunella grandiflora	0.91^{abc}	28.3^{a}	5.65	2.43^{bcde}	9.30^{a}	0.90
Ranunculus acris	0.95^{ab}	24.2^{c}	4.87	1.88^{e}	8.27^{ab}	0.67
Trifolium repens	0.63^{de}	27.8^{ab}	4.24	2.46^{bcd}	6.49^{bc}	0.76
Veronica chamaedrys	0.87^{abc}	24.1^{c}	5.61	1.99^{de}	7.91^{ab}	0.61
Significance	**	**	NS	**	**	NS
RMSE	0.12	1.73	1.10	0.36	1.40	0.28

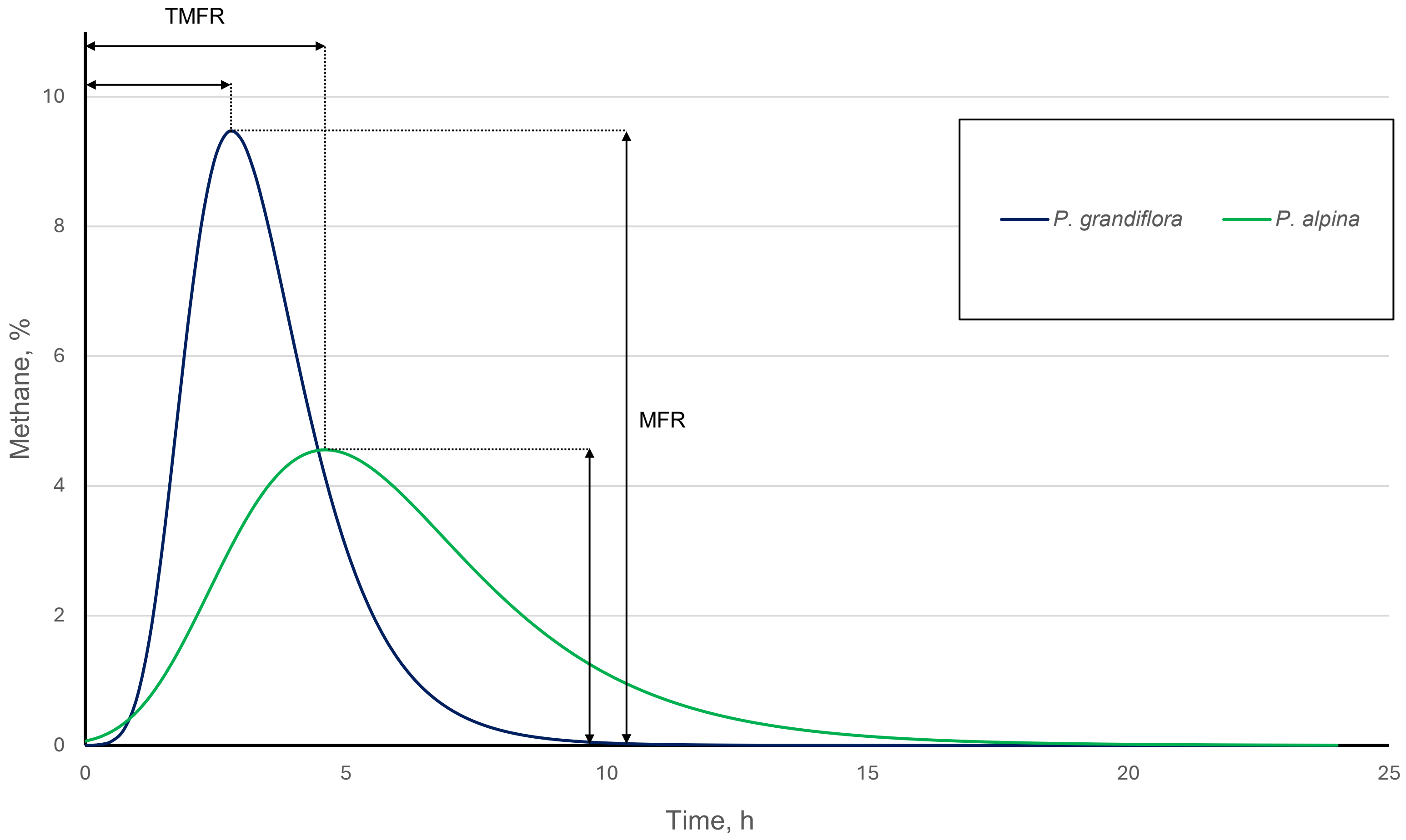
Results and Discussion

Methane yield

	CH4 (%)	A	C (1/h)	TMFR (h)	MFR (%/h)	Lag (h)
Poa alpina	26,7	0,43	4,30	2,88	4,89	0,73
Prunella grandiflora	26,6	0,91	5,65	2,43	9,30	0,90

- Prunella grandiflora: intense but short-lived production of CH4

-Poa alpina: prolonged CH4 production over the time but less intense



Conclusion

In vitro gas production systems are widely used to rapidly detect methane resulting from the ruminal fermentation of several substrates, including plant species

The chemical composition of plants influences fermentation

None of the examined plants drastically reduce CH4

The study of kinetics allows for the differentiation of plants that only appear to be similar (after 24 h of fermentation)

Acknowledgements

This study was funded by the European Union - **NextGenerationEU**, in the framework of the consortium iNEST - Interconnected Nord-Est Innovation Ecosystem (PNRR, Missione 4 Componente 2, Investimento 1.5 D.D. 1058 23/06/2022, ECS_00000043 – Spoke1, RT2, CUP I43C22000250006) and in the framework of **DM 737/2021** (University of Udine).

Thanks for
your kind attention!